SECTION I. DATA COMPILATION AND ANALYSIS

Introduction

Development of a comprehensive data base is necessary so that: (1) a base line of water quantity and quality can be established and be available for comparison to that previously acquired or collected or predicted in the future. It is also important to future decision making that such a data base be presented and interpreted in a clear fashion in a single document. (2) The construction of both a numerical flow model and a water quality monitering program rests on a good data base.

The procedure which we will follow for data base line development is (a) collection of existing data; (b) synthesis of data into graphics, charts, tables, etc.; (c) interpretation, with emphasis on needed field data; (d) collection of field data; (e) inclusion of new data and synthesis into a final report.

Specific Work Items

A literature search will be performed, both in Tucson and in Albuquerque, with particular assistance from U.S.G.S. and B.I.A. Special attention will be paid to locate sources and include their data. Maps, drawings, and tables will be included in a working report which (1) shall show well data, potentiometric surfaces, transmissivities and hydraulic conductivities, surface

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floors, withdrawal, other hydrologic information in the project area. (2) The report shall incorporate geologic data into proper form for construction of a hydrologic numerical flow model. Detailed cross sections, isopach maps, outcrops, extent of aquifer units, faulting, and volcanics shall be included. (3) The report shall show background water quality, geochemical boundaries, water chemistry relationships with time, geology, and human activities. Point, line, and diffuse pollutant sources shall be identified and delineated on maps and drawings.

During and after working report preparation a preliminary interpretation of the data shall be made with particular emphasis on the need for additional field data. These might include pump tests, standard quality analysis, carbon-14 dating (which could give information on transmissivities), halocarbon dating (Thompson 1979), isotopic fractionation analyses, total alpha, radium, uranium, and radon analyses.

These new data will be assimilated into the working report so that they can be incorporated into the numerical model and water quality monitoring program. After further interpretation, the working report will be refined and converted into the first part of the final report: the present status of the quality and quantity of the water resources of the Pueblo of Laguna.

SECTION II. PROPOSED NUMERICAL MODELING WORK

Introduction

The numerical modeling to be performed under this contract will consist of developing a regional ground water flow model to assist in the estimation of the effects of ground water withdrawals for uranium mining and milling on the water resources of the Pueblo of Laguna. The areal extent of the model will be sufficient to evaluate the behavior of the Jurassic aquifers under the reservation and to a distance of at least 60 miles north of the northern boundary of the reservation. The vertical coverage of the model will be sufficient to evaluate spring flows on the reservation, but will depend on the extent of interaction between the Jurassic aquifers and the surrounding water bearing units.

Specific Work Items

The numerical model will be used to assist in defining the present head distribution and pattern of ground water movement in the Westwater and Jackpile members of the Morrison Formation, including discharges to the land surface. The model will also be used to estimate the natural head distribution and flow patterns which existed before artificial withdrawals from the aquifers began ("steady state"). Finally, the model will be used to evaluate the future response of the aquifer system and associated springs and streams to predicted withdrawals for uranium mining and milling, and other relevant withdrawal uses through the year 2030.

Requirements of the Modeling Technique

Although the specific modeling technique to be used for this work cannot be specified at the present time, the hydrogeologic characteristics of the study area place certain constraints on the choice of method.

First, the Jurassic aquifers probably cannot be treated as an isolated system due to leakage to and from surrounding aquifers through confining beds and along fault zones. For this reason, the model must be capable of handling multiaquifer problems.

Second, the region is characterized by relatively small areas of heavy withdrawals and large areas of small withdrawals. Accurate results in areas of heavy withdrawals requires use of a detailed numerical grid while computer storage and time limitations necessitate using coarse grids in areas of small hydraulic gradients. To handle these requirements for a regional model, flexibility in grid design is highly desirable. The complex geologic structure in some parts of the study area, especially the Rio Puerco Fault Belt, also necessitates use of a fully three-dimensional model with a flexible grid design.

A large part of the modeling work will be devoted to analyzing the effect of withdrawals from the aquifers on spring flow. When flowing, the springs represent constant head hydraulic boundaries, but the possibility that some of the springs may cease flowing due to pumpage requires that the model be able to handle time variant boundary conditions.

Description of Possible Modeling Techniques

Three existing computer programs are available which can meet all or part of the above requirements. The three-dimensional finite difference program developed by Trescott (1975) appears to be capable of handling the multiaquifer regional flow aspects of this study. The rectangular grid requirements of this model, however, may limit its ability to accurately simulate both regional flow and flow in areas of heavy withdrawals. In addition, the complex geology of the Rio Puerco Fault Belt may be difficult to handle with this model.

An integrated finite difference model known as TRUST capable of handling three-dimensional problems is also available. A distinct advantage of this model is that it does not require a rectangular grid. This feature greatly enhances its ability to simulate areas of steep hydraulic gradients and complex geology in regional flow problems. The integrated finite difference method is described in Narasimhan and Witherspoon (1976).

A computer program known as FLUMP, which uses the finite element method, is also available for use on this problem. FLUMP has all of the advantages of TRUST with the additional capability of handling anisotropic hydraulic conductivity. Modifications of FLUMP would be required to handle the multiaquifer aspects of this study and for this reason, FLUMP probably will not be used unless anisotropy proves to be a significant factor in the area. The numerical approach used in FLUMP is described in Narisimhan and others (1978).

Although every effort will be made to handle all aspects of this study with the regional model, the complex hydrogeology of some parts of the study area may necessitate developing local models. Use of local models will, however, be limited to the analysis of specific problems.

Model Calibration and Analysis of Results

The numerical model constructed under this contract will be calibrated by attempting to use it to duplicate historical water level data. The quality of the calibration will depend on the quality and quantity of hydrogeologic data available on the study area. For this reason, precise calibration cannot be guaranteed at the present time. In addition, when assumptions about hydrogeologic properties must be made, emphasis will be placed on the hydrologic reasonableness of the assumptions rather than their ability to force the model to match historical records.

Use of the model to predict the impact of future ground water withdrawals will be based as much as possible on existing scenarios of ground water exploitation in the area. If the predictions show that a scenario results in hydrologically unreasonable effects, simulation of that scenario will be terminated. For example, a particular scenario could result in lowering the piezometric surface below the top of a confined aquifer. In such an event, simulation of that scenario will not extend beyond the time when the unrealistic effect occurs.

The results of the model simulations will be presented in the form of maps and cross sections showing the piezometric surface and flow patterns, water level change maps, and spring hydrographs with textual interpretation of the results. In addition, the model results will be incorporated in the other hydrologic analyses performed under this project.

SECTION III. PROPOSED WATER QUALITY MONITERING DESIGN PROGRAM

Introduction

The monitering program to be designed under this contract must accomplish the following goals: (1) Identify information necessary for the verification of the study projections and detection of changes in quality of reservation water resources. (2) Evaluate the results which may be obtained from the monitoring program in light of the costs involved so as to obtain the most effective program. (3) Implement a continuing monitering program.

In order to accomplish these goals, the monitering program must meet several requirements. The program should be designed with the particular geologic, hydrologic and geochemical characteristics of the area in mind. A generalized format will not suffice. Both present and future potential pollution sources should be considered. The program should be created with the foresight and flexibility to deal with future development. Potential pollution sources and pollutants should be evaluated in light of the volume produced, the toxicity, and the present and

projected water utilization on the reservation. Hydrologic, geologic and chemical factors which may alter the pollutants after release must be included. Finally, the program must be designed in full cognizance of present monitering efforts, so as to be comprehensive while avoiding duplication.

Proposed Methodology

The monitering program to be designed under this contract will utilize the methods presented in Monitering Ground Water Quality: Monitering Methodology, by Todd et al., 1976, published by the U.S. Environmental Protection Agency. This carefully thought-out methodology fulfills all of the requirements stated above. The major disadvantage of this methodology is that it is intended only for ground water monitering. However, with minor modifications, this approach is readily applicable to coupled ground water-surface water systems.

Several advantages will results from the use of this methodology. Its explicit nature will allow evaluation at any time of the progress of the project and its accomplishments. It will also ensure continuity in the event of personnel changes. The use of a standard, EPA published methodology will facilitate comparison of this project with government sponsored projects of similar goals and ease cooperation between them.

Finally, in the event that the results of the monitering program are needed as a basis for official action, the ability to